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# *Non-chemical control of kumara rots after washing*

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# Contents

# 1 Executive summary

We carried out a literature review seeking alternatives to the fungicide Botran® (a.i. dicloran) for control of rots in kumara after washing and prior to consumption. We concluded that hot water treatment is the most likely alternative to fungicide treatment and that improved sanitation may also offer an opportunity to reduce reliance on fungicide treatment.

We visited three packhouses and talked to packhouse operators and growers. We carried out two hot water drench (HWD) trials to evaluate the potential of hot water for control of rots in washed kumara. Despite low incidence of rots in our trials we concluded that HWD has potential to control rots and that more work is needed to confirm this potential.

# 2 Introduction

Kumara (known internationally as sweet potato) are prone to soft rots (mainly *Rhizopus* spp.) after washing and prior to retail sale. For many years kumara packhouses have relied on Botran® 75WP fungicide (a. i. 750 g/kg dicloran) to minimise rots in washed kumara. Finding an alternative to Botran® is vital for the kumara industry because:

- Retailers and consumers in New Zealand are seeking elimination of use of postharvest fungicides, and
- New export markets are opening up for postharvest fungicide-free New Zealand kumara.

Unpublished results obtained from sweet potato trials in Israel suggest that hot water treatment has the potential to replace Botran®. Dr E Fallik (pers. comm.) found a 20 second hot water rinsing and brushing (HWRB) treatment at 52°C reduced rots in storage, with no rots after 2 weeks (vs 8% untreated) and 15% incidence after 3 months (vs 45% untreated). The HWRB technology is a patented technology (but only in Israel). We believe hot water drenching (HWD), which is a similar technology to HWRB, is a viable, simple and relatively cheap alternative that should be evaluated for rot control on washed kumara.

This report reviews the research literature on rot control options for washed sweet potatoes and reports on results from initial HWD trials. The project brings together Crop & Food Research knowledge of postharvest handling of kumara (D Brash) and plant pathology expertise (Dr L-H Cheah) and HortResearch knowledge of heat treatment and equipment for HWD (Dr A Woolf).

# 3 Literature review

Fungal infection of sweet potato can occur in the field, during harvest operations, in storage and during washing and packing prior to retail. Control of postharvest diseases centres on prevention, since little can be done once the root is infected. Care must be taken to minimise damage and prevent infection through proper sanitation during harvest and postharvest handling (Kays 2007). Boyette et al. (1997) outline the traditional fungicide-based approach towards prevention of rots in washed sweet potatoes. Fungicide is applied either by dipping the roots into a tank of chemical solution or by spraying as the roots pass along a roller conveyor. Both of these methods are used in New Zealand. The recommendation is 150 g Botran® 75WP per 100 litres of water for 2500 kg of kumara, with a top-up of 10 g Botran® 75WP for a further 1000 kg kumara.

Boyette et al (1997) also noted the importance of good sanitation. They point out that, no matter how careful the operation, decay-producing organisms will be brought into the packhouse along with the sweet potatoes. These organisms will quickly contaminate all working surfaces and remain viable for months if not removed. The authors suggest daily hosing down of produce handling equipment and floors to remove dirt and decayed produce. They suggest regular disinfection of equipment using a strong chlorine solution. Removal of decaying roots from the whole packing area is also recommended.

Rhizopus soft rot (caused by *Rhizopus stolonifer*) is the most destructive and widespread postharvest disease of sweet potato worldwide, according to Holmes & Stange (2002). Those authors examined the influence of wound type and storage duration on susceptibility of two sweet potato cultivars to Rhizopus soft rot, and found that roots were totally resistant to infection after harvest for 60 days in year 1 and 30 days in year 2. The bruise wound type was most commonly associated with infection (more than puncture, broken and scrape wound types). Disease incidence peaked after 100 and 175 days after harvest in years 1 and 2 respectively, and the susceptibility of roots declined to levels similar to that of freshly harvested roots.

As noted above, Dr E Fallik provided unpublished results suggesting that HWRB has potential to control post-washing rots in sweet potatoes. HWRB is a patented technology, although the patent only applies to Israel. A review (Fallik 2004) summarised the impact of hot water treatments on harvested horticultural crops and suggested that reduction in decay development in treated fresh produce from hot water dips and HWRB was mainly attributable to a 3–4 log reduction (i.e. a 99.9–99.99% reduction) of the total microbial colony forming units (CFU) of the epiphytic micro-organism population, compared with untreated produce. The review showed that there were applications for 19 horticultural crops but not for use on sweet potatoes. The review does not mention HWD, which we are evaluating. HWD uses a shower of hot water and this technology, developed by HortResearch, has advantages over the more passive dipping method. HWD achieves more rapid heat exchange, and temperature changes are more even throughout the treated fresh produce.

Scriven et al. (1988) have shown that hot water dipping has potential for control of decay in sweet potatoes. They tested treatments over a wide range of conditions (40–100°C for 2–240 s) and found that some treatments substantially delayed the time to initial rot development. Interestingly, the best treatments were 90°C for 2 s, 80°C for 2, 4 or 10 s and 40°C for 120 s i.e. mainly at high temperatures.

Afek & Orenstein (2003) found that a short exposure to steam prior to storage reduced rots in storage. After 5 months of storage the percentage of decayed roots in cured sweet potatoes was 3% for steam treatment and 5% for fungicide treatment, compared with 32% for an untreated control. Steam temperature was 90°C for 10 s at the root surface. Similar results were obtained at a commercial packhouse using 70°C and a 6 s contact duration.

Another non-chemical treatment that shows potential to enhance resistance to rots in sweet potatoes is the use of a low dose of ultra-violet light–C. Stevens et al. (1999) showed that treated roots showed an increase in resistance to Fusarium root rot (caused by *Fusarium solani*). Microbial antagonists have also been tested: Ray & Das (1998) reported complete growth inhibition by three antagonistic yeasts against Java black rot (caused by *Botryodiplodia theobromae*).

As noted above, good sanitation is an important part of kumara rot control. Kumara coming into a packhouse are likely to have microbial contamination from decayed roots among the stored roots. Kumara are normally washed to remove soil and fungal contaminants and then are given a 'cleanup' by treatment with a sanitising agent, either chlorine (calcium or sodium hypochlorite) or Nylate (a.i. bromo-chloro-dimethylhydantoin). Nylate is a registered processing aid (washing agent) available in New Zealand for postharvest washing of fresh produce.

Examination of the effectiveness of washing and sanitising methods suggest the following (from Sapers 2001):

- Chlorine effectiveness is markedly reduced by the presence of organic matter in soil and on product surfaces. Peroxyacetic acid (e.g. Tsunami) has also been recommended but efficacy is similar to chlorine. It should be noted that both of these materials are highly effective against micro-organisms suspended in water and so are suited to reducing microbial populations in recirculating water systems. Thus, these sanitisers help to prevent or reduce the risk of produce cross-contamination.
- Handling methods during washing and packing should be as gentle as possible because fungal contaminants that end up in bruises, punctures and cracks are likely to be inaccessible to the action of sanitising agents.
- Delays between contamination and treatment will allow micro-organisms to become firmly attached and, as a result, will be more difficult to control.
- Presence of a biofilm might cause re-contamination of produce on a packing line. A biofilm is an extracellular polysaccharide matrix that holds the cells together and glues them to surfaces, such as on processing equipment. In this state, micro-organisms are more resistant to detachment or inactivation by washing treatments.

An examination of the effectiveness of washing and sanitising procedures in kumara packhouses has not yet been undertaken, but could be valuable. Two of the authors (D Brash and L-H Cheah) worked with carrot packhouse operators and believe that removal of biofilms from wet packing lines, using a daily cleanup with quaternary ammonium biocides, helped to reduce fungal infection in export carrots (Cheah & Brash 2001).

# 4 Visit to Dargaville packhouses

D Brash, L-H Cheah, A Woolf, R Jackman and S Olssen visited three packhouses and spoke to packhouse operators on 12 October 2006. There was a clear desire from growers and packhouses to find alternatives to Botran®. Interest in the planned HWD trial was high and packhouse managers summarised their own efforts to reduce reliance on Botran® through use of new sanitisers.

Kumara were cleaned (washed to remove dirt) and given a sanitising rinse in clean water (with added Nylate or chlorine) before fungicide treatment. Botran® was applied by either spray nozzles on the packing line or by dipping kumara in a Botran-treated water dump. Kumara were dried (or partially dried) after treatment and before packing.

# 5 Hot water drench trials

## 5.1 Methods

We chose to carry out the HWD trial at New Zealand Kumara Distributors (NZKD) Ltd packhouse. The layout of this packhouse allowed easy access to remove washed kumara from the packing line for trials. Close by, there was an area available for setting up and running the HortResearch experimental scale HWD machine.

### 5.1.1 HWD treatment

The hot water drencher consisted of a drenching frame positioned inside a 90 L water bath containing three 2.1 KW temperature controllers set to the desired temperature. Hot water was pumped into a reservoir positioned at the top of the apparatus using a Grundfos 245 W pump. Holes measuring 4 mm in diameter were drilled into the bottom of the reservoir at 15 mm by 15 mm spacing. Flow rate through the drencher was 200 L/min. Below the reservoir a plastic coated wire-mesh tray containing a single layer of kumara was inserted into the apparatus for drenching. All sides of the apparatus were enclosed with perspex. Water depth inside the reservoir was 30 mm. Water temperature was monitored inside the reservoir.

### 5.1.2 *Trial setup*

The trials were carried out on 9 November 2006. Roots from a range of growers were run through the grading line (bin dump followed by cold water brushing) until just prior to the Botran® dip. Nylate sanitiser was used during cold water brushing. At this stage the roots were removed and treated using a matrix of temperatures and durations (50, 52.5, 55 and 57.5°C for 15, 30, 45 and 60 seconds). Two different control treatments were used for comparison with HWD treatments. The first control was an 'Untreated control' in which roots went through the washing and rinsing process in the packhouse and were removed just prior to the Botran® dip. The second control was a 'Botran control' in which roots went through the full commercial washing and rinsing process, the Botran® dip, and subsequent drying.

We also compared the response to HWD using kumara from four different sources, using four grower suppliers of NZKD Ltd. The four grower suppliers were named K, F, P and R.

### 5.1.3 *Trial designs*

Trial 1: Temperature x duration comparison using kumara from grower K.

In this trial we compared 14 treatments at four temperatures (50, 52.5, 55, 57.5°C) x three durations (15, 30, 45 seconds) plus two controls (Untreated control and Botran control).

Trial 2: Three grower lines and three durations compared at 52.5°C

In this trial we compared 15 treatments: three grower lines (F, P and R) x five treatments (three durations: 15, 30, 45 seconds) plus two controls (Untreated control and Botran control).

Each treatment was replicated three times. Each plot was treated separately (drenched in a separate run) and consisted of 35 kumara, making a total of 105 kumara for each treatment.

After treatment the kumara were dried using domestic fans and packed into standard cardboard cartons.

### 5.1.4 *Transport, storage and assessment*

Kumara were transported using non-refrigerated transport to Turners & Growers Ltd and then to Crop & Food Research in Palmerston North. Kumara from Trial 1 arrived on 10 November and from Trial 2 on 13 November. On arrival the kumara were placed into storage at 20°C and 90% relative humidity. Two storerooms were used. Both rooms have Carel humidification systems to maintain relative humidity at 90%. All cartons from each replicate were stored in a group in one of the storerooms.

Kumara from untreated control treatments (420 kumara) were checked for incidence of rots twice a week for 4 weeks then every 2–3 weeks for a total storage period of 10 weeks (9 November 2006 to 26 January 2007). All of the kumara were checked for incidence of rots and appearance at the end of storage.

## 5.2 Results and discussion

We expected soft rots to develop quickly in the untreated control treatment, because this is what often happens commercially if kumara are not treated with Botran®. In our experiments rots did not develop in the 3–4 weeks after washing. Levels of rots were very low (0.9%). We decided to keep the kumara in storage to see whether rots would develop with a longer storage duration.

After 10 weeks a full assessment was made of incidence of rots and of kumara appearance. Rot levels were 1.1% for Trial 1 (16 of 1470 kumara in trial) and 0.2% for Trial 2 (three of 1575 kumara in trial).

The proportions of roots with rots present were analysed using Binomial Generalised Linear Model. For Trial 1, we split the treatments up by Type (Untreated control, Botran and HWD) and then by Temperature and Duration for the HWD treatments. We found there was a significant difference between Types ($P$=0.008) and Temperatures of HWD ($P$=0.016) but not between Durations ($P$=0.185) nor a Temperature x Duration interaction ($P$=0.233). Higher temperature seem to risk more rots. Results are summarised in Table 1.

*Table 1: Proportion of kumara with rots (95% confidence interval). Significance column indicates difference from Untreated control.*

| Treatment | % Rots (95% CI) | Significance |
|---|---|---|
| Untreated control | 4.8 (1.6–10.8) | |
| Botran control | 0.0 (0.0-3.5) | $P$<0.05 |
| HWD, 50°C | 0.0 (0.0–1.1) | $P$<0.001 |
| HWD, 52.5°C | 0.6 (0.1–2.3) | $P$<0.05 |
| HWD, 55°C | 1.0 (0.2–2.8) | $P$<0.05 |
| HWD, 57.5°C | 2.2 (0.9–4.5) | |

For Trial 2, there were almost no rots and there were no significant differences between growers ($P$=0.211), nor the five treatments ($P$=0.249), nor any interaction ($P$=0.998).

We closely examined the appearance of kumara from trial 1 for damage. We identified a number of kumara which had lost pigment (changing from purple/red to a light pink colour) and had a more wrinkled skin (probably because of higher weight loss as the roots appeared to have shrunk as well). The damage did appear to be related to high temperature and longer duration of exposure. We found 10 kumara with symptoms, one at 55°C/45 seconds, three at 57.5°C/30 seconds and six at 57.5°C/45 seconds. We cut open a number of roots and found no evidence of changes to flesh colour across all treatments.

We expected higher levels of rots in untreated kumara in our trials. We discussed the results with growers and there was a view that the prevalence

of rots is higher during winter months. This observation supports the research findings of Holmes & Stange (2002) reported earlier. They found the period of peak susceptibility was 3 months after harvest in one year and 6 months after harvest in another year (between June and August in New Zealand). Duration of susceptibility differed between the two cultivars tested. The promising results from this trial suggest the need for more work to confirm the benefits of HWD and a need to carry out the trials at a time of year when infection rates are expected to be higher (i.e. resistance to infection is lower).

# 6 Conclusion

Despite low levels of rots in the trials, the results suggest that HWD has potential to control kumara rots after washing, particularly in the 50–55°C temperature range. Further research is required to further define the optimum temperature and duration for HWD treatment.

# 7 Recommendations

From the literature review and trials we recommend:

1. Further trials to define the optimum temperature and duration for HWD treatment,
2. Trials to be carried out using a 50–55°C temperature range and 15–45 seconds treatment duration,
3. Trials to be carried out on kumara that are susceptible to developing rots in storage, possibly collected in winter, and
4. An evaluation of current packhouse sanitation procedures and, if appropriate, an assessment of the benefit of an enhanced packhouse cleaning procedure.

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